II. *An Account of some Experiments, performed with a View to ascertain the most advantageous Method of constructing a Voltaic Apparatus, for the Purposes of Chemical Research.* By John George Children, *Esq. F.R.S.*

Read November 24, 1808.

THE late interesting discoveries by Mr. DAVY, having shewn the high importance of the VOLTAIC battery, as an instrument of chemical analysis, it became a desirable object to ascertain that mode of constructing it, by which the greatest effect may be produced, with the least waste of power and expense.

For this purpose, I made a battery, on the new method, with plates of copper and zinc, connected together by leaden straps, soldered on the top of each pair of plates; which are twenty in number, and each plate four feet high, by two feet wide: the sum of all the surfaces being 92160 square inches, exclusive of the single plate at each end of the battery. The trough is made of wood, with wooden partitions well covered with cement, to render them perfectly tight, so that no water can flow from one cell to another. The battery was charged with a mixture of three parts fuming nitrous, and one part sulphuric acid, diluted with thirty parts of water, and the quantity used was 120 gallons.

In the presence, and with the kind assistance of Messrs. DAVY, ALLEN, and PEPYS, the following experiments were made.

*Experiment* 1. Eighteen inches of platina wire, of $\frac{1}{30}$th of an inch diameter, were completely fused in about twenty seconds.

*Exp.* 2. Three feet of the same wire were heated to a bright red, visible by strong day-light.

*Exp.* 3. Four feet of the same wire were rendered very hot; but not perceptibly red by day-light. In the dark, it would probably have appeared red throughout.

*Exp.* 4. Charcoal burnt with intense brilliancy.

*Exp.* 5. On iron wire, of about $\frac{1}{70}$th of an inch diameter, the effect was strikingly feeble. It barely fused ten inches, and had not power to ignite three feet.

*Exp.* 6. Imperfect conductors were next submitted to the action of the battery, and barytes, mixed with the red oxyde of mercury, and made into a paste with pipe-clay and water, was placed in the circuit; but neither on this, nor on any other similar substance was the slightest effect produced.

*Exp.* 7. The gold leaves of the electrometer were not affected.

*Exp.* 8. When the cuticle was dry, no shock was given by this battery, and even though the skin was wet, it was scarcely perceptible.

Before I offer any observations on the inferences to be drawn from these experiments, I shall mention some others, performed, for the sake of comparison, with the foregoing, with an apparatus very different in size and number of plates, from the one just described.

This second battery was precisely the *Couronne des Tasses* of Sig. VOLTA, consisting of two hundred pairs of plates, each about two inches square, placed in half pint pots of common

queen's ware, and made active by some of the liquor used in exciting the large battery, to which was added a fresh portion of sulphuric acid, equal to about a quarter of a pint to a gallon.

To state as shortly as possible the effects produced by this battery:

*Experiment* 1. It decomposed potash and barytes readily.

*Exp.* 2. It produced the metallization of ammonia with great facility.

*Exp.* 3. It ignited charcoal vividly.

*Exp.* 4. It caused considerable divergence of the gold leaves of the electrometer.

*Exp.* 5. It gave a vivid spark, after being in action three hours. At the expiration of twenty-four hours, it retained sufficient power to metallize ammonia, and continued, with gradually decreasing energy, to produce the same effect, till the end of forty-one hours, when it seemed *nearly* exhausted.

From the results of the foregoing experiments, which though simple and not numerous, I trust, are satisfactory; we see Mr. DAVY'S theory of the mode of action of the VOLTAIC battery confirmed: he says (in his Paper on some Chemical Agencies of Electricity, Sect. 9. after having shewn the effect of induction to increase the electricity of the opposite plates), "the *intensity* increases with the *number*, and the *quantity* with the *extent* of the series."

That this is so, the effects produced on the platina and iron wires, in the first and fifth experiments with the large battery, and the subsequent experiments on imperfect conductors, with the small apparatus, sufficiently prove. The platina wire being a perfect conductor, and not liable to be oxydated, presents no obstacle to the free passage of the electricities through it,

which, from the immense quantities given out from so large a surface, evolve, on their mutual annihilation, heat sufficient to raise the temperature of the platina to the point of fusion.

With the iron wire, of $\frac{1}{70}$th of an inch diameter, the effect is very different, which is explained by the low state of the intensity of the electricity (sufficiently proved by its not causing any divergence of the gold leaves of the electrometer), which being opposed in its passage by the thin coat of oxide, formed on the iron wire, at the moment the circuit is completed, a very small portion only of it is transmitted through the wire. To the same want of intensity is to be attributed the total inability of the large battery to decompose the barytes, and its general weak action on bodies which are not perfect conductors. The small battery, on the contrary, exerts great power on imperfect conductors, decomposing them readily, although its whole surface is more than thirty times less than that of the great battery; but in point of number of plates, it consists of nearly ten times as many as the large one. The long continued action of the small battery, proves the utility of having the cells of sufficient capacity to hold a large quantity of liquor, by which much trouble of emptying and filling the troughs is avoided, and the action kept up, without intermission, for a long space of time, a circumstance, in many experiments, of material consequence. Besides this advantage, *with very large combinations*, a certain distance between each pair of plates is *absolutely necessary*, to prevent spontaneous discharges, which will otherwise ensue, accompanied with vivid flashes of electric light, as I have experienced, with a battery of 1250 four-inch plates, on the new construction. And here I beg leave to mention an experiment, which, though not

directly in point, cannot be considered as foreign to the subject of this Paper. It has been urged, as one proof of the non-identity of the common electricity, and that given out by the VOLTAIC apparatus, that in the latter there is no striking distance. That objection, however, must cease. I took a small receiver, open at one end; through perforations in the opposite sides of which were placed two wires, with platina points, well polished: one was fixed by cement to the glass, the other was moveable, by means of a fine screw, through a collar of leathers, and the distance between the points was ascertained by a small micrometer attached. This receiver was inverted over well dried potash over mercury, and suffered to stand a couple of days, to deprive the air it contained, as thoroughly as possible, of moisture. The 1250 plates being excited precisely to the same degree as the great battery, mentioned in the beginning of this communication; and the little receiver placed in the circuit, I ascertained its striking distance to be $\frac{1}{50}$th of an inch. That I might be certain that the air in the apparatus had not become a conductor by increase of temperature, I repeated the experiment several times with fresh cool air, and always with the same result; but perhaps it will be objected, that the striking distance was so small, as not to afford a satisfactory refutation of the argument alluded to, when it is considered to how very great a distance, comparatively, the spark of the common electrical machine can pass through air. The answer to this is obvious: increase the number of the plates, and the striking distance will increase; for we see throughout, the intensity proportioned to the number, and it probably may be carried to such extent, as even to pass through a thicker plate of air, than the common spark.

The great similarity of the appearance of the electric light of this battery in vacuo, and that of the common machine, might also be urged as an additional proof of the identity of their nature.

The effect of this large combination on imperfect conductors, was, as may be supposed, very great; but of the same platina wire, of which the four-feet plates fused eighteen inches, this battery melted but half an inch, though, had the effect been in the ratio of their surfaces, it should have fused nearly fourteen inches.

The absolute effect of a VOLTAIC apparatus, therefore, seems to be in the compound ratio of the number, and size of the plates: the intensity of the electricity being as the former, the quantity given out as the latter; consequently regard must be had, in its construction, to the purposes for which it is designed. For experiments on perfect conductors, very large plates are to be preferred, a small number of which will probably be sufficient; but where the resistance of imperfect conductors is to be overcome, the combination must be great, but the size of the plates may be small; but if quantity and intensity be both required, then a large number of large plates will be necessary. For general purposes, four inches square will be found to be the most convenient size.

Of the two methods usually employed, that of having the copper and zinc plates joined together only in one point, and moveable, is much better than the old plan of soldering them together, through the whole surface, and cementing them into the troughs: as, by the new construction, the apparatus can be more easily cleaned and repaired, and a double quantity of surface is obtained. For the partitions in the troughs,

glass seems the substance best adapted to secure a perfect insulation; but the best of all, will be troughs made entirely of WEDGWOOD'S ware, an idea, I believe, first suggested by Dr. BABINGTON.